# Lifetime of ALD-coated microchannel plate PMTs*

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Microchannel-plate photomultipliers (MCP-PMTs) are the preferred photon sensors for the PANDA DIRC detectors for hadron identification. They reach a sub 50 ps time resolution and can be used for single photon detection in magnetic fields up to 2 Tesla [1]. MCP-PMTs are available as multi-anode devices with a good gain uniformity and a moderate cross talk among the anodes [2]. The main drawback until recently was a serious aging problem caused by feedback ions from the rest gas hitting and damaging the photo cathode (PC). This results in a fast diminishing quantum efficiency (QE) while the integrated anode charge increases [3].

Approaches such as higher tube vacuum, electron scrubbing of the MCP surfaces, protection films or modified PCs were tested by the manufacturers to increase the lifetime of MCP-PMTs. The breakthough against the aging issue finally came with the application of an atomic layer deposition (ALD) technique: in a sophisticated procedure the MCPs are coated with an ultra-thin layer of usually $Al_2O_3$ or MgO which significantly reduces the desorption of atoms from the MCP material. In 2011 PHOTONIS was the first manufacturer to supply us with a prototype of an ALD-coated MCP-PMT (9001223) to measure its lifetime.

In Fig. 1 the results of a comparative measurement of several types of MCP-PMTs are shown which is ongoing since 2011. By a simultaneous illumination within an environment similar to PANDA conditions the systematic uncertainties are minimized and a fair comparison of the different tubes is possible. For monitoring purposes the pulse heights are continuously recorded at a highly prescaled rate during the illumination. Spectral and spacial QE scans are performed every few days/weeks or months, respectively. From the plots it is obvious that the lifetime of the recent MCP-PMT models has tremendously increased in comparison to former tubes (open dots at the left side of the figure).

In the ALD-coated PHOTONIS MCP-PMT (9001223) the degradation of the QE starts after 6 C/cm$^2$. This is seen in Fig. 1 and in the QE chart of the whole PC surface in Fig. 2 (upper right), where the left half shows a significantly reduced QE. No sign of aging is observed yet at 5 C/cm$^2$ in another MCP-PMT (9001332) with the same specifications [4]. In both tubes the right half of the PC is not illuminated.

In our comparative aging measurement (see Fig. 1) we have meanwhile identified three MCP-PMTs (PHOTONIS XP85112 9001223 and 9001332; Hamamatsu R10754X-07-M16M KT0001) which fulfill the PANDA requirement

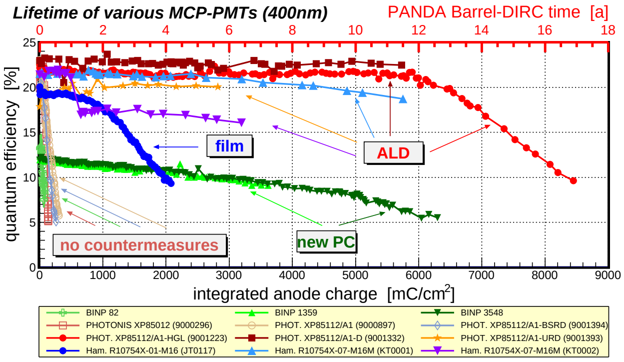


Figure 1: QE at 400 nm for old (open) and recent, lifetime-enhanced (solid dots) MCP-PMTs versus the anode charge.

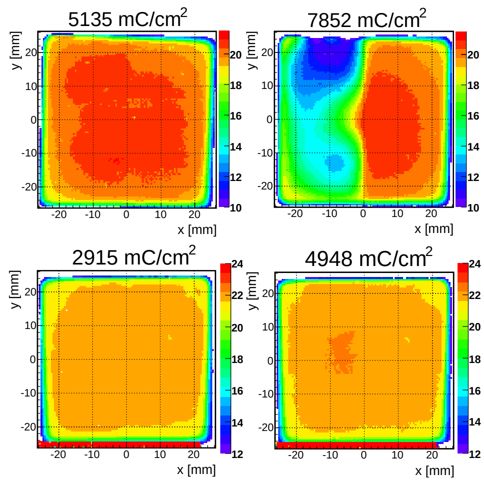


Figure 2: QE at 372 nm as a function of the PC surface for two XP85112 MCP-PMTs: 9001223 [upper row] and 9001332 [lower row]. In both tubes the right half ($x > 0$) of the PC was covered during the whole illumination.

of an integrated anode charge of >5 C/cm$^2$ without a significant QE degradation. This is an important result because it implies that after several years of investigations we have finally found photon sensors that survive the high rate environment at the DIRC focal planes for at least 10 years.

## References

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